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Post-Flight Chest Discomfort in Aviators: Aero-Atelectasis

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SUMMARY

Three jet pilots recently flew high G bank maneuvers, while breathing 100% oxygen and wearing anti-G harnesses, as part of an in-flight project for weapons systems development. As a consequence, on more than one occasion, all three pilots experienced shortness of breath, cough, and aching in the chest - this latter symptom persisted as long as 3 hours following flight. Physical examination was unremarkable. Pulmonary function study revealed a reduction in vital capacity, immediately following flight, of 20-28% as compared to pre-flight levels outside the plane. A partial, reversible collapse of lung tissue ("aero-atelectasis") may be the mechanism for the observed finding, which could conceivably contribute to aircraft accidents, if not modified.

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INTRODUCTION

Within the last five years, several authors have published accounts of a post-flight chest syndrome (1, 2, 3, 4). In a number of instances, pilots or aircrew members have complained of a variety of symptoms, particularly chest pain, cough, or difficulty in breathing. Physical examination generally has been unrewarding, although in some instances basilar rales and/or diminished breath sounds have been detected posteriorly. X-ray changes have been more striking, revealing linear or plate-like basilar opacification, consistent with atelectasis. Pulmonary function studies in some instances have revealed decreased vital capacity, increased respiratory rate, and reduction in expiratory reserve volume. A spectrum of findings has been observed in the subjects reported upon: that is, some symptomatic subjects have had X-ray and pulmonary function abnormalities, whereas asymptomatic subjects had X-ray abnormalities only occasionally. In the most severe cases, a common denominator appears to have been the presence of three factors: acceleration exposure, oxygen breathing, and anti-G suit utilization.

CURRENT PROBLEM

Recently, three jet pilots at the Naval Air Development Center, Johnsville, Warminster, Pennsylvania were required to fly "high G" profiles (from +4.0 to +5.0 G_z ("positive")) for an instrument development project to perfect an automatic pilot for the QF9J aircraft, as part of a program of weapon systems development for the Bureau of Naval Weapons. The pilots were required to fly at an altitude of 15,000 ft., at an average speed of 375 knots, for a total flight time of approximately one and one-half hours, during which they flew alternating 360° bank maneuvers at an average angle of 75°. A typical flight sequence would involve fifteen alternating bank maneuvers, wherein the pilot experienced the high G forces for approximately 45 seconds; following the acceleration exposure, the pilot would fly "straight and level" for approximately two and a half minutes before entering the next bank maneuver. All pilots flew alone in the aircraft, utilizing 100% oxygen from a liquid oxygen generator system, supplied by a Robertshaw-Fulton 17600 series mini-regulator and an A13-A oxygen breathing mask. Each pilot flew the typical flight profile once every three or four days for several weeks.

SYMPTOMS

On numerous occasions during their flying periods, all three pilots experienced a tightening sensation in the mid-precordium, associated with a desire to cough. Frequently, they complained of difficulty in taking a full breath while experiencing the peak acceleration load during the bank maneuver. At the completion of the flights all pilots frequently complained of some residual aching and soreness at the xiphoid area, which would last for two to three hours.

EXPERIMENTAL PROCEDURE

In order to assess the significance of the variable complaints, which did not occur on every flight in every pilot, it was decided to make some simple measurements of pulmonary function in each pilot. Utilizing a McKesson model VC-25 "Vitalor"* (Figure 1) each pilot performed breathing tests before and following one typical high G flight. Following maximum inspiration, a maximum expiration was performed, with recording of vital capacity on special graph paper. Figure 2 is a sample graph showing results of vital capacity measured under five conditions. One-second timed vital capacity and maximum expiratory flow rate were extrapolated from the graph. Thus, three measurements were made with the "Vitalor": a vital capacity (VC), a timed vital capacity after one second (TVC_1) and a maximum expiratory flow rate (MEFR) (5). The pilot was tested in the following conditions:

1. Sitting upright in pilots' lounge, clothed with flight suit, Z-3 anti-G harness, integrated torso harness, and "hard hat" helmet.

2. Sitting upright on the Martin-Baker ejection seat in the cockpit of the QF9J aircraft, prior to breathing oxygen before takeoff.

3. Sitting in the cockpit, immediately after removal of the oxygen mask post-flight.

4. Within five minutes of the completion of flight, sitting in the cockpit of the plane.

5. Within fifteen minutes of completion of a flight, after walking, then sitting upright with all flight gear on in pilots' lounge.

RESULTS

Table I shows a tabulation of the findings of the three measurements made on the three subject pilots (WRR, AEW, JFW). In Condition 1, each pilot had normal measurements when sitting upright on a chair in the pilots' lounge, fully clothed in all of his flight gear, before takeoff. In Condition 2, however, each pilot had a reduction in his vital capacity, while sitting in the cockpit of the aircraft, prior to breathing oxygen. Immediately following a flight, a measurement was made as soon as the pilot removed his oxygen mask after landing. The results (Condition 3) showed a 21 to 28% reduction in vital capacity from the pre-flight level outside of the plane, and a 13 to 20% reduction from the pre-flight level recorded in the cockpit. Following a deep

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* McKesson Appliance Company, Toledo, Ohio

Figure 1. Portable Vital Capacity Test Device ("Vitalor", McKesson Co.).

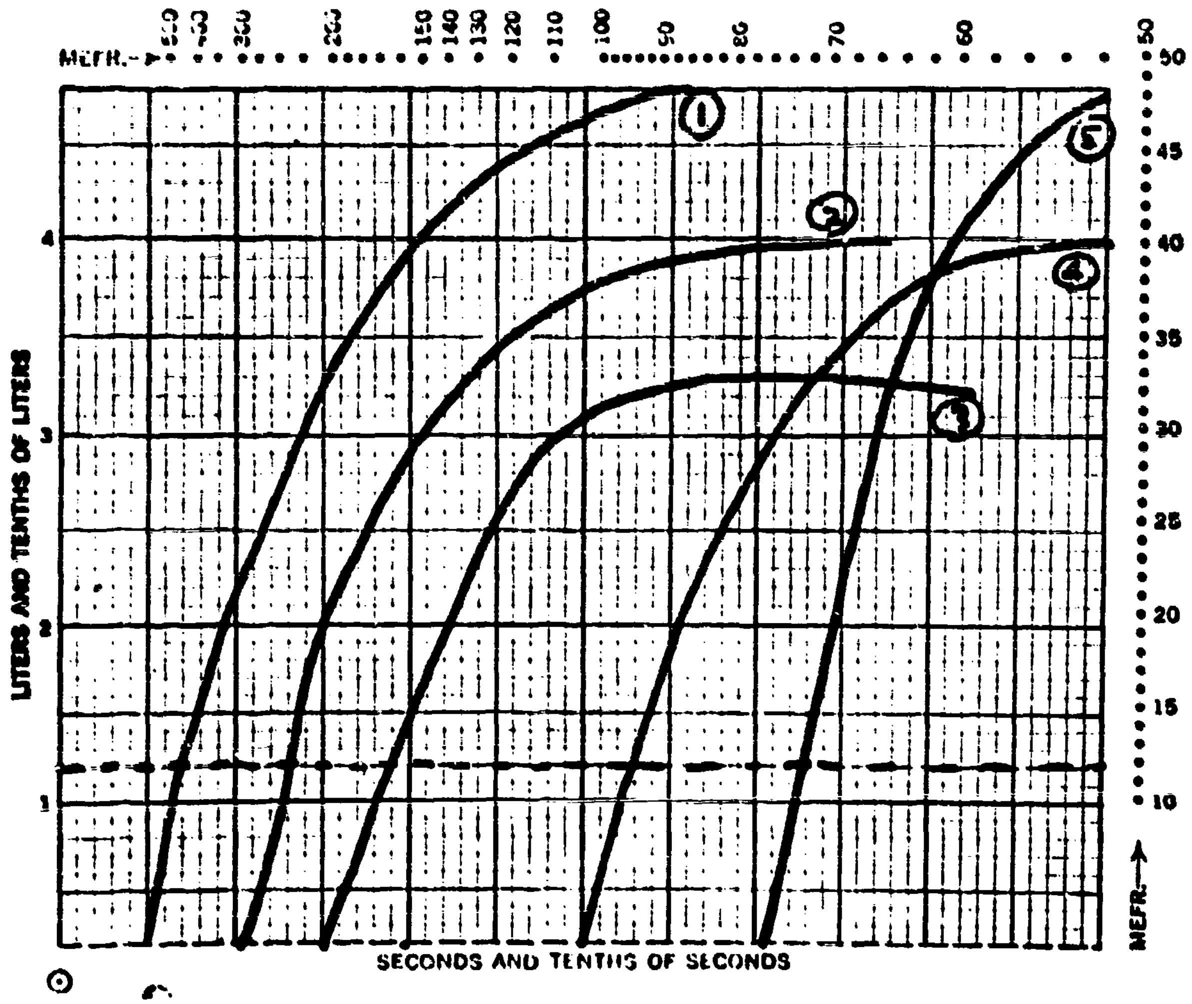

Figure 2. Sample Graph of Pilot WRR, showing results of vital capacity measured under 5 conditions.

RESPIRATORY MEASUREMENTS

Experimental Conditions	Vital Capacity N=100%± 10			Timed Vital Capacity 1 sec (normally 80%+ of total)			Max. Expiratory Flow Rate > 300 Liters/min. (Normal Males)		
	WRR	AEW	JFW	WRR	AEW	JFW	WRR	AEW	JFW
Normal	4.5	4.5	4.3	3.8	3.8	3.7	300	300	300
Condition 1 Lounge Pre-flight	5.0 (111%)	5.0 (111%)	4.2 (97%)	4.0	4.8	3.7	375	350	450
Condition 2 Plane Pre-flight	4.0 (89%)	4.8 (107%)	4.0 (92%)	3.3	3.7	3.4	500	325	375
Condition 3 Plane Post-flight	3.3 (72%)	3.5 (77%)	3.5 (79%)	2.9	3.0	3.2	280	300	300
Condition 4 Plane Post-flight	4.0 (89%)	3.9 (87%)	3.7 (85%)	3.8	3.2	3.2	300	300	275
Condition 5 Lounge Post-flight	4.5 (100%)	4.4 (98%)	4.2 (97%)	3.9	4.0	3.6	300	325	400

breath or two, a repeat measurement was made in the cockpit (Condition 4) and improvement in the vital capacity was noted. After walking from the plane to the pilots' lounge, the pilot was re-evaluated while sitting upright wearing all of his flight gear (Condition 5): in all cases, "normal" measurements were obtained in that circumstance. Maximum expiratory flow rates were within normal limits, except for one subject immediately following flight, (Subject WRR, Condition 3) and one subject approximately five minutes following flight (Subject JFW, Condition 4): both of these measurements, however, were very close to the normal range. Timed vital capacities after one second were above 80% of the vital capacity made at the same time, except on one occasion when it was 77% (Condition 2, AEW).

DISCUSSION

All pilots were most reluctant to discuss their discomfort during the actual project: only by a chance remark overheard about "chest soreness and high G profiles" did the author suspect that some measurable physiological change might have occurred, so that each pilot was persuaded to fly the "test" profile on one occasion only, in order to allow a breathing measurement to be made. No pilot experienced difficulty in controlling the aircraft during the "test" profiles flown. The findings which may be of interest are:

1. Wearing flight gear and sitting in the cockpit caused a measurable reduction in the vital capacity in the three pilots concerned.

2. All three pilots had symptoms, both during the flight and immediately following the flight, although no physical abnormalities were noted.

3. Immediately following flight (involving high G stress, 100% oxygen and an anti-G suit) all three pilots had a significant decrease in the vital capacity (P less than 1/125).

"Aero-atelectasis", or the "post-flight" chest syndrome", is most likely to occur in pilots exposed to high G forces, breathing oxygen, and utilizing an anti-G suit (1,2,3). No new information is available about the mechanism, which appears to be a transitory atelectasis (2,3,4). Flight surgeons should be alerted to the possibility of this problem occurring in high-performance jet pilots and aircrew, so that careful assessment of these personnel can be made periodically in an effort to prevent accidents. Although there were no serious consequences with the three pilots during their recently-completed project; nevertheless, should they have flown for more prolonged periods, or more frequently, the very real possibility of "an accident waiting to happen" cannot be dismissed. Furthermore, the use of a simple portable pulmonary function machine, which the author and others (5) have found to be a most helpful adjunct in the clinical assessment of cardiopulmonary complaints can serve as a useful test device for the flight surgeon stationed far from sophisticated pulmonary physiology facilities.

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